

Transforming AMC Test & Evaluation: Using Effects-Based Mobility and AFSO21 to Build a Direct Investment into Air Force Modernization and Recapitalization

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From 2008 to 2013, American taxpayers will spend over 30 billion dollars to increase the global maneuverability of the American Military. Central to this investment is verifying that dollars invested by the USAF Air Mobility Command (AMC) yield the effects they were intended to produce. Upcoming programs include the KC-X, Joint Cargo Aircraft (JCA), and a variety of modernization/recapitalization (modern/recap) programs for the C-5, C-130, C-130J, KC-10, KC-135 and C-17. With an increasing amount of AMC operational test workload on the horizon, standing up a traditional test and evaluation (T&E) organization seems like a viable option. Unfortunately, large personnel reductions needed to support modern/recap make garnering manpower a challenging task to advocate with the corporate Air Force. However, the authors met this challenge by re-building an organization that represents a direct investment into modern/recap. They conducted a six-month study and concluded that a “right sized” operational test force increases potential for cost reduction, because it is lean enough to create savings for Air Force modern/recap programs. In order to achieve this vision, the authors used an emerging doctrine called Effects-Based Mobility (EBM) to connect the joint fight with the T&E Enterprise. The authors also used Air Force Smart Operations (AFSO21) to pinpoint shortfalls in the existing organization and quantify potential cost savings. When used together, this analysis cut overhead and transformed the organization into a predictive, lean organization that represents a direct investment into Air Force Modernization and Recapitalization programs.

A. Application

This paper is intended to report the results of an effects-based and AFSO21 approach toward “right sizing” a T&E organization. It is mostly geared toward DOD acquisition professionals, especially in the T&E Enterprise. Therefore, the concepts and terms provided assume readers have a basic understanding of T&E as it applies to DOD acquisition. On the other hand, the approaches presented are also deeply rooted in industrial engineering and operation management techniques and have a wide range of technical and business applications. Concepts such as Lean, Six-Sigma, and Linear Programming were used to quantify organizational performance and provide decision-making tools for transformation. Therefore, readers are encouraged to explore the concepts presented in order to apply to other organizations.

B. Background: Mapping a Resource-Constrained T&E Environment

Test and Evaluation is a risk-reducing tool acquisition managers utilize for weapon system development programs. Testing gauges progress made when a system moves from an idea to a product.³ Adequate testing ensures weapon systems progress through DOD acquisition milestones by verifying specification compliance (Developmental Testing) followed by an evaluation of mission effectiveness and suitability (Operational Testing). The ultimate goal of T&E is to ensure a system works as intended before it is provided to the customer.

The DOD allocates a variety of test resources to support T&E objectives for weapon system acquisition. From wind tunnels and environmental test facilities to large test range complexes, test resources ensure weapon systems are measured in a robust fashion. Another key portion (and arguably the most important) is the T&E workforce, which provides test and operational expertise to design and execute experiments that evaluate system performance. Testers ensure systems meet required specifications, and are effective and suitable in accomplishing their intended mission.

C. Test & Evaluation Challenges

Often times the success or failure of an acquisition program depends on its performance during testing. Program managers (PM) rely on T&E to measure system performance to determine if a system is ready to progress from

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development to fielding. PMs primarily fund T&E, which often takes the form of support for resources, planning, execution and reporting. Some funding represents the overhead cost required for upkeep of assets mentioned in the previous paragraph. PMs integrate this funding into a five-year budget cycle. In this cycle, competing programs across the services vie for funding in front of Congress.

With this backdrop, one can see the challenges faced by PMs and how this shapes interactions with the T&E force. Funding T&E is a costly endeavor. Robust testing is often the key to finding and fixing critical deficiencies before fielding a system. However, with the discovery of deficiencies comes the reality of the “Bad Press” effect. Bad press, in the form of negative test results, can result in reduced confidence in system performance. Reduced confidence forms a perception of poor performance, which significantly affects the standing of competing programs in front of Congress. Thus, a potential question considered by nearly every program managers is,

“Why would I pay for resources that could uncover system deficiencies impacting future funding, or even the survival of my program?”

This is not to say unethical practices form the basis of PM strategy. Rather, it is safe to say the “Law of the Jungle” takes over when it comes to weapon system survival. Keeping programs “alive” often occupies the mindset of PMs, who deal with a myriad of acquisition challenges. Life-cycle savings can sometimes take a back seat to competing service priorities in a resource-constrained environment.

With this frame of reference, forces are easily aligned to perceive T&E as an entity that increases program costs and generates bad press leading to program delays, or even cancellation. The momentum to “field first” and rectify later often results in over budget situations as systems require expensive retrofits.

With PMs engaging the purse strings of the acquisition environment, it is easy to see the challenge the T&E enterprise faces toward building an infrastructure capable of effectively reducing program risk. From a historical perspective, a series of acquisition reforms in the 1990s steadily strained T&E manning. During the “Lightning Bolt Initiatives,” policy makers placed greater stock in contractor-supported testing. As contractors bid on T&E for major programs, Air Force leadership justified further reductions in the T&E Enterprise but did little to explore the secondary effects of this action on weapon system cost overruns. Making the situation even more challenging are the current PBD 720 budget cuts, where the T&E community is experiencing substantial cuts to its manpower force. With aging national test facilities, leaders are again asking the question: How can we improve the effectiveness of T&E, and what is the right size of our Enterprise?

D. MAJCOM T&E: New Challenges Presented to Air Mobility Command

Air Mobility Command T&E is faced with similar challenges as the command moves to invest in modern/recap of its fleet. Since the days of Military Airlift Command, AMC has relied on a small MAJCOM T&E Enterprise. With a manpower force of approximately 99 personnel, AMC testers kept pace with OT&E obligations, maintained oversight of DT&E programs, and met rapid fielding requirements.

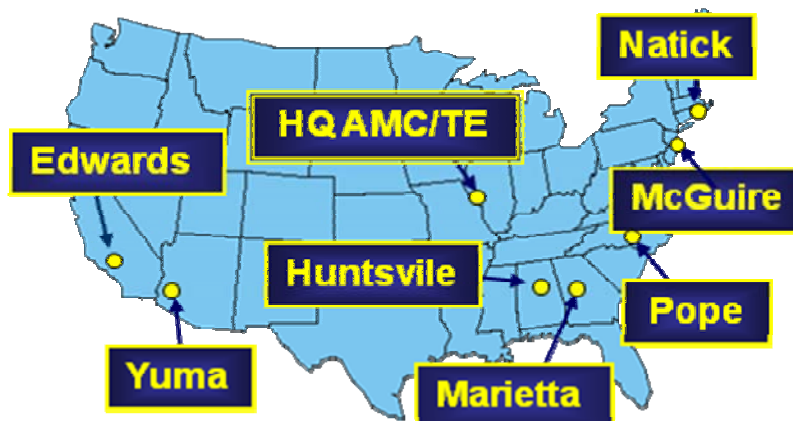


Figure 1. The Current AMC T&E Enterprise is shown above (99 billets consisting of 73 permanent and 26 temporary positions). The TE organization includes a headquarters location, a single squadron at McGuire AFB, and various detachments and operating locations positioned throughout the CONUS.

A single Squadron conducted Follow-on Test and Evaluation (with Det's and Operating Locations shown in Figure 1), while AFOTEC assumed responsibility for Initial Operational T&E (IOT&E). Given the Low Density, High Demand nature of mobility assets and manpower, aircraft were not permanently assigned to the OT&E Enterprise (as in ACC and AFSOC). AMC T&E relied primarily on temporary assignment of aircraft and aircrews for test execution.

For the most part, the AMC T&E Enterprise met AMC's T&E requirements in the 1990s and early 2000s. The C-17 program completed IOT&E with AFOTEC, and a robust DT community assumed responsibility of block upgrades. Moreover, Air Logistics Centers assumed responsibility of incremental upgrades for other mature systems, such as C-5, C-141, KC-135, and C-130. This structure also met congressionally mandated workload brought about by the tragic loss of a T-43 aircraft in Dubrovnik, Yugoslavia and a C-141 mid-air collision in Africa.

Award of the C-5 modernization program required the addition of 20 temporary positions to the AMC T&E Enterprise. It appeared as though the AMC T&E Enterprise was appropriately sized for future workload. By the year 2000, Headquarters AF T&E policy makers shifted all IOT&E workload toward AFOTEC and transferred approximately 40 positions from AMC to AFOTEC.⁴

However, the start of the Global War on Terror brought significant change to the AMC landscape. AMC investments grew in 2001, and AFOTEC deferred C-17 and C-130J workload toward AMC MAJCOM testers. The AMC T&E Enterprise faced increasing workload which included rapid fielding initiatives like Joint Precision Airdrop Systems (JPADS) and Mobility Defensive System Testing. At the same time a myriad of modern/recap programs rocketed to the forefront of AMC's priorities. Modernization of the C-5, C-130, KC-10, and KC-135 added significant workload to the AMC T&E Enterprise. AMC investments from FY08 to FY13 are estimated at \$30 billion, as shown in Figure 2.⁵ The substantial increase in investment, when overlaid with AMC T&E manpower uncovers a potential challenge in the ability of the T&E force to mitigate increasing investment risks. Such an environment poses several questions:

1. Is the AMC T&E Enterprise properly sized to mitigate risk for this investment?
2. In a resource-constrained environment what changes, if any, are required?

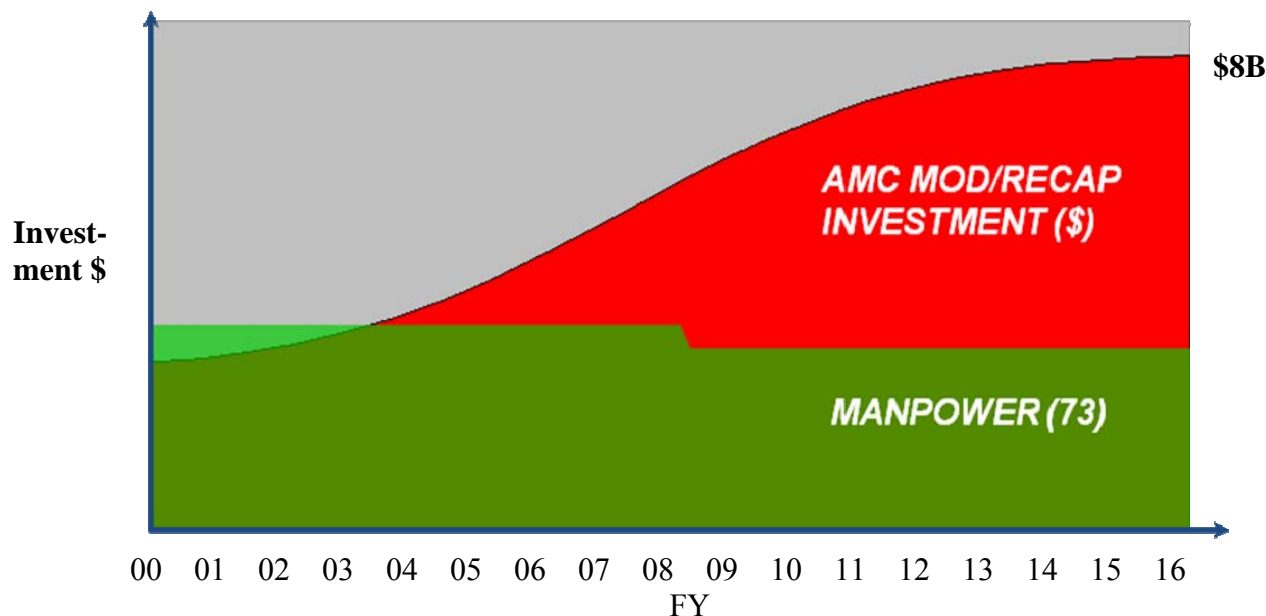


Figure 2. HQ AMC modern/recap investment (\$34B FY08-13), overlaid with AMC T&E manpower levels.⁶

The authors set out to answer these questions by using Effects-Based Mobility (EBM) and Air Force Smart Operations 21 (AFSO21). EBM is an emerging air mobility doctrine that focuses efforts on "Critical Factors" that generate effects.⁷ The authors used EBM to build a connection between the Joint Fight and the T&E Enterprise. They also used AFSO21 to look for adverse indicators of the changing landscape, shown in Figure 3. AFSO21 is the Air Force Vision for achieving greater organizational efficiency.⁸ It combines the principles of Lean, Six Sigma, Theory of Constraints, and other Operations Management techniques traditionally utilized in manufacturing and industrial engineering fields.

The authors started their analysis by examining problem areas in major AMC programs. Two programs served as a model for this analysis. The first program was the C-5 Avionics Modernization Program (AMP). The second program was the C-130 AMP. The authors' investigation of both programs uncovered indicators of instability in both of these programs, primarily in the form of cost overruns and schedule delays. The figure below shows the current state of C-5 AMP and projection of C-130 AMP. C-5 AMP is currently 17% over budget, while C-130 AMP is at 128% percent over budget.⁹

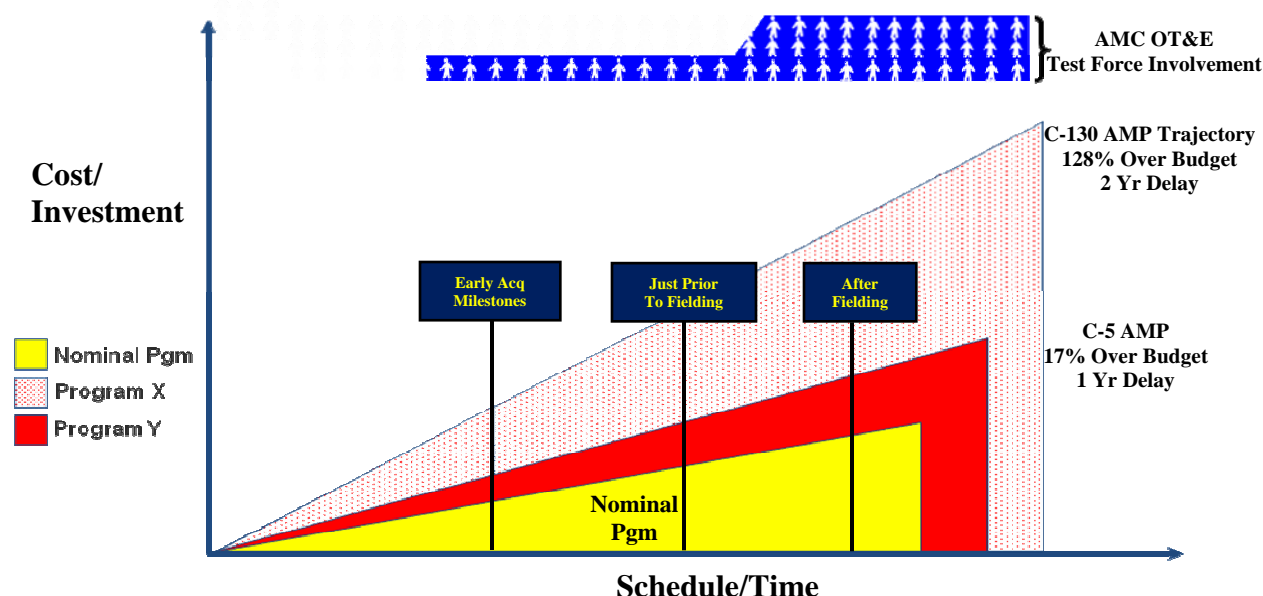


Figure 3. Indicators of Program Instability.¹⁰

With overruns exceeding Nunn-McCurdy Amendment breaches and garnering significant Congressional oversight, it is easy to conclude that these programs are experiencing instability. However, determining the T&E link to these programs is a more challenging task. Analysis of C-5 and C-130 modernization programs determined that both programs proceeded to test with relatively unstable designs. The unstable designs resulted in schedule delays. With schedule pressures, program managers sought to “make-up” time by compressing test schedules. With a schedule scoped for a given manpower level, accelerating schedules increased T&E manpower requirements and strained resources. The C-5 AMP was fielded prior to acquiring critical knowledge most often collected during testing. The C-5 also fielded with excessively large lists of software defects. In the end, this cascading phenomenon resulted in expensive redesigns, retrofits, and delayed delivery to the warfighter, shown in Figure 3. The C-5 program, shown in solid red, experienced a 17% cost increase, and 1 year delay in development. The trajectory of the C-130 AMP program, shown in dotted red, depicts a 128% cost increase, and a 2 year delay in fielding.¹¹ Now note the blue bar at the top of Figure 3. It depicts the level of involvement the AMC T&E Enterprise has in mobility development programs. Notice how the current AMC Test Force presents forces more toward the back end of development, where the least amount of influence in cost can be made. This construct is primarily reactive in nature. At this point the authors recognize that Air Force Regulations dictate that AFOTEC takes a leading role in OT&E involvement, which is not reflected in Figure 3. What the authors focused on was the link between MAJCOM OT&E involvement and program stability. The reactive nature of the AMC construct led the authors to investigate the link between T&E resources and program performance in greater detail.

The authors used AFSO21 to conduct a “Root Cause” analysis of data reported by the Secretary of Defense’s Director of Operational Test and Evaluation (DOT&E) in its annual report. The analysis mapped critical improvement areas identified by DOT&E, and found compelling results for mobility programs. DOT&E looked at 27 Major Air Force programs in 2005 and came up with the major improvement areas shown in Figure 4.

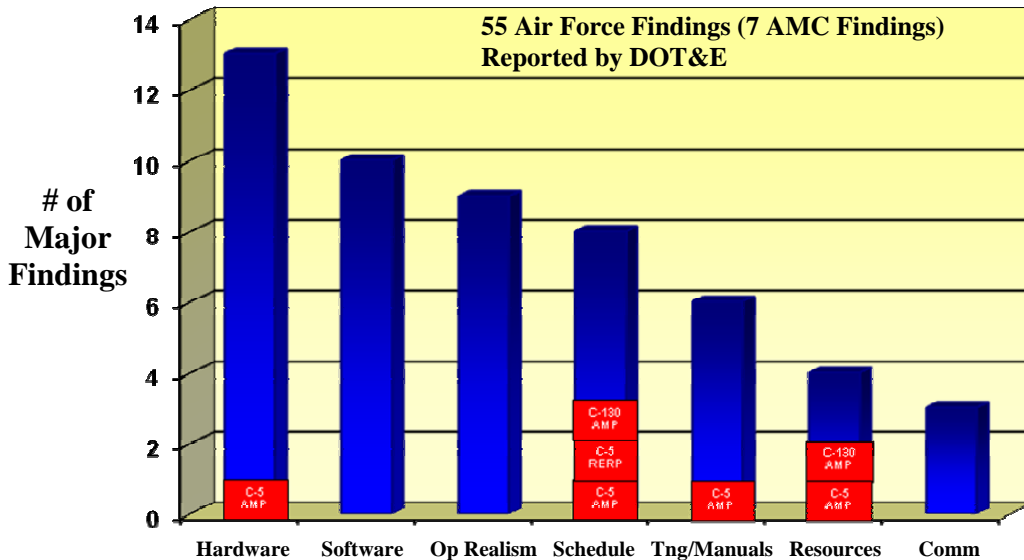


Figure 4. FY06 DOT&E Improvement Areas for 27 Air Force Programs.¹²

As expected, hardware, software and operational realism topped the list of Air Force improvement areas. On the contrary, improvement areas for AMC reflected a different focus. For mobility programs, spikes centered around resources and schedule. The authors determined that limited test resources, in the form of aircraft sourcing, manning, and early program involvement were constraining development efforts, resulting in unrealistic schedules, unstable software systems, and immature systems integration. A study conducted by RAND further concluded that shortages in operational test manpower currently serve as a barrier to realistic and early testing.¹³ The correlation between manning, schedule and resources are complex. However, the authors concluded this T&E shortage poses a significant impact on AMC's ability to achieve critical knowledge at key program milestones. This analysis provided key indicators that an AMC T&E transformation could reduce some of the instability encountered in major modern/recap programs.

In the process of analyzing problem areas in the AMC T&E Enterprise, the authors concluded that findings could be indicators of a greater Air Force T&E Enterprise problem. In a recent address, The Honorable Sue Payton, Under Secretary of the Air Force for Acquisition remarked, "We are a country at war, and we have to find the money to do the things we have to do, like Precision Airdrop. We do not have a seamless acquisition system. It is a build-up of stovepipes. But we are working very hard to build a seamless system."¹⁴ With these remarks in mind, the authors sought to create a new way of thinking to build a stronger, more seamless connection between the T&E Enterprise and the joint fight. Central to this new way of thinking is changing the perception of the T&E Enterprise as a cost increasing endeavor.

E. Building a New Way of Thinking using Effects-Based Mobility and AFSO21

The authors used two methods to develop a way to transform AMC T&E. The first method involves a new cutting-edge doctrine in AMC called Effects-Based Mobility, or EBM. EBM leverages mobility systems in order to generate greater effects for the joint fight. It pushes leaders to select "CRITICAL FACTORS" that connect organizational output to actual battlefield effects.¹⁵ While the systems-thinking concepts in EBM are very close to Effects-Based Operations common in the Air Force strike community, EBM adds tools specific to Mobility Air Force (MAF) needs in order to maximize joint effects. The authors married this concept to AFSO21, which combined a review of best business practices in T&E as well as specific AFSO21 optimization tools in order to eliminate waste, "right size," and organize the future AMC T&E force. When used together, EBM provided focus on critical factors connecting T&E to the joint fight, while AFSO21 provided the tool bag to quantify improvement areas.

F. EBM Connects T&E to the Joint Fight

Effects-Based Mobility compels leaders to establish a systems approach to generating effects for Joint Forces. For AMC, it starts with the commander's intent, provided by General Duncan McNabb, the former AMC

Commander.¹⁶ In AMC, Velocity and Precision are critical enablers that generate effects for the joint fight at the Strategic, Operational, and Tactical level of war (see Figure 5).

As you can see from Figure 5, the top-down analysis started with a review of the effects AMC generates for the joint fight. As EBM dictates, organizations must first determine critical factors that generate effects. In AMC, VELOCITY and PRECISION enable mobility forces to generate the effects shown on the right side of Figure 5. The authors determined the AMC T&E Enterprise enables VELOCITY and PRECISION by verifying the mission effectiveness of key weapon systems used by mobility forces. Therefore, **Mission Impact** was identified as a critical factor. At the same time, AMC T&E also has a profound impact on the cost of acquisition programs. Finding and correcting defects early in the acquisition life cycle of a system can significantly reduce the cost of a program. Therefore, **Program Cost** was identified as another critical factor. Identifying Mission Impact and Program Cost as critical factors focused the study to those areas that enable greater effects for the joint fight.



Figure 5. MAF Effects and Commander's Intent Formed the Basis for Analysis.

G. Using AFSO21 to "Right Size" the AMC T&E Enterprise

So far in the study, several sub-optimum areas were uncovered in the T&E Enterprise (primarily manpower and resources, as shown in Figure 4). EBM connected these sub-optimum areas to the commander's intent, and AFSO21 pinpointed manpower and resources as potential sore spots; so what now? Figure 3 provides clues. Shifting AMC manpower forward in the acquisition process could provide significant cost gains in major modern/recap programs. Will simply adding manpower across the board maximize the output of the organization? How much manpower should be added? Will returns outweigh the investment? By how much? Quantifying these numbers with a credible business case could unlock the key to establishing a greater bond between program managers and the T&E community. In other words, how do we know the returns are worth the investment in T&E?

In order to answer these complex questions, the authors blended several methods rooted primarily in the operation's management field. The authors first modeled the AMC T&E Enterprise using a linear programming technique called the Analytical Hierarchy Method.¹⁷ The model allowed leaders to quantify decision-making priorities to maximize mission impact and reduce cost. By modeling the AMC T&E Enterprise from a manpower perspective and matching that model to the critical factors of **Mission Impact** and **Program Cost**, an optimized organizational build could be established. Most importantly, the results could be quantified in order to provide senior leaders with a baseline for comparison, to include cost estimation. Equation 1, shown below, describes the model, the total output in annual hours of the AMC T&E Enterprise.

$$M = \sum_{K=1}^n (T_1 + T_2 + \dots + T_n)_1 + (T_1 + T_2 + \dots + T_n)_2 + \dots + (T_1 + T_2 + \dots + T_n)_K \quad (\text{Equation 1})$$

Where:

M = The total time per year devoted to test program planning, execution and reporting

T = Hours devoted by a member of AMC/TE toward an AMC Test Program in 1 year

K = Number of organizations in the AMC/TE organization

N = Number of members in each AMC/TE squadron, detachment, or operating location

M is the total output of the AMC T&E Enterprise in hours/year devoted to a list of 44 current projects in AMC. The total represents only hours dedicated to project planning, execution, and reporting. It did not count administrative overhead, support hours, or other activities associated with T&E organizations. Equation 2 is the normally distributed density function of the product of **Mission Impact** and **Program Cost**, the two critical factors identified as critical factors.

$$F(x) = \frac{1}{\sigma} \left(\frac{x - \mu}{\sigma} \right) \quad (\text{Equation 2})$$

Where:

F = The normally distributed hierarchy, x, between mission impact and program cost

μ = The mean of the probability density function

σ = Standard Deviation of the probability density function

x = The product of critical factors, based on an hierarchy index, of 1-10 (see Figure 6)

The product of the critical factors, x, was achieved by reviewing AMC programs with respect to the critical factors and conducting a weighted comparison of program priorities. As shown in Figure 6 (left side), some programs like Aeromedical Evacuation, rate high on mission impact but are relatively low in cost. Others, like KC-X, rate high in both mission impact and program cost. When normally distributed, the majority of AMC T&E workload consists of mid-range values, as shown in Figure 6 (right side).

$$\text{Output improvement (\%)} = \frac{(M \times F)_{\text{current org}} - (M \times F)_{\text{new org}}}{(M \times F)_{\text{current org}}} \quad (\text{Equation 3})$$

Then the authors calculated the product of M and F, which produced a non-dimensional representation of the total output. Using Equation 3, the authors compared the output of various organizational builds by percentage. Maximizing percentage output completed the model and provided decision-making options based on critical factors. Since the change in percentage was based on man-hours dedicated to projects, percentage increases were converted back to man-hours in order to quantify cost savings.

The authors ran the model with a variety of organizational builds and compared output to the current state. Overall, positioning AMC T&E personnel toward earlier involvement optimized this complex system. When compared to the original plan, using the Analytical Hierarchy Method allowed AMC to increase output by 17 %. The fidelity of the model lies with the authors' understanding of the level of effort provided to each program. In other words, the numbers provided did not include a sum total of hours worked by each individual in a given year. Such a value would not have the sensitivity to influence Mission Impact and Program Cost. Rather, the authors only included hours of direct support provided by AMC testers. Administrative positions and support activities reduced the sensitivity of the model, so they were not included in the simulation.

The authors also developed greater efficiencies in the resourcing of test aircraft. Since mobility aircraft are considered high-demand assets, minimizing aircraft absence from the warfighter is key to increasing the critical factor Mission Impact. Improved aircraft sourcing techniques, to include greater participation in integrated DT/OT efforts, reduced AMC flight test hours by 30%. Added to this was an effort to integrate knowledge management tools in order to forecast future workload and combine test efforts when possible.

An important aspect of this transformation is that it was not conducted in a vacuum. Throughout the study, the authors connected with Headquarters Air Force AFSO21 core process teams and utilized knowledge management to integrate with AFSO21 T&E efforts in AFMC and AFOTEC. They conducted several meetings with experts in the aerospace industry and government organizations like NASA, the FAA, and RAND. AMC also conducted a review

of industry best practices, including a review of T&E successes on the Boeing 777 program, as well as Intel™ software improvement programs.¹⁸ These efforts enabled the authors to conclude that a small investment in AMC T&E Transformation could yield large program savings.

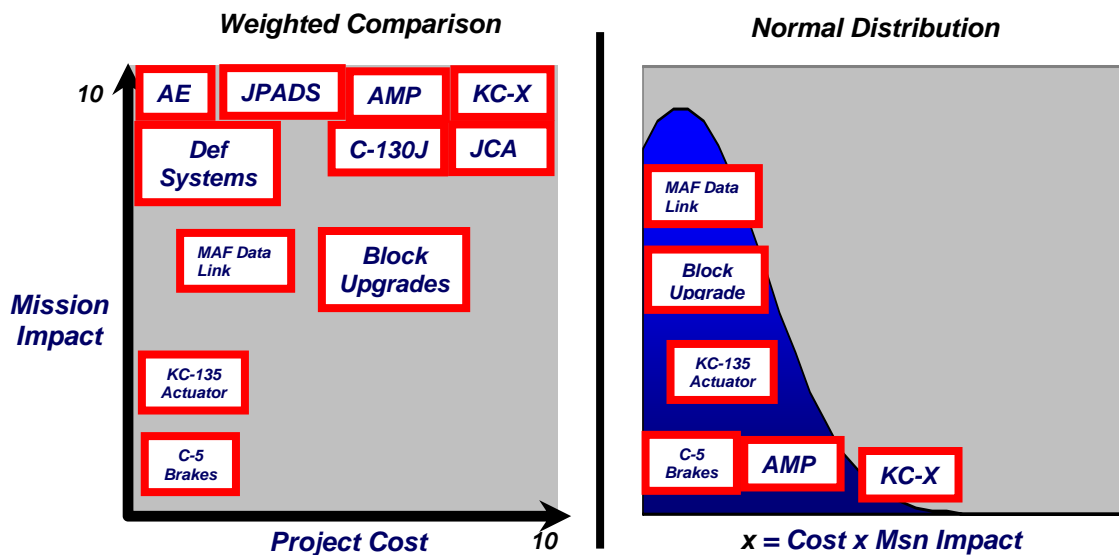


Figure 6. Weighted analytical hierarchy of T&E critical factors aimed at maximizing joint effects

The AMC Transformation plan will result in a lean and efficient organizational design that positions AMC involvement earlier in the acquisition life cycle of a program. Program office liaisons were developed for early involvement at product and logistics centers for KC-X, KC-135 and C-5 modernization programs. More positions were moved to Edwards AFB to place greater emphasis on integrated DT/OT programs and maximize the use of scarce resources. Additionally AMC teamed with the Air Reserve Component in order to leverage expertise in tactics, defensive and communication systems. The manpower plan incorporated a phased approach in order to retain the flexibility to move personnel as workload levels change.

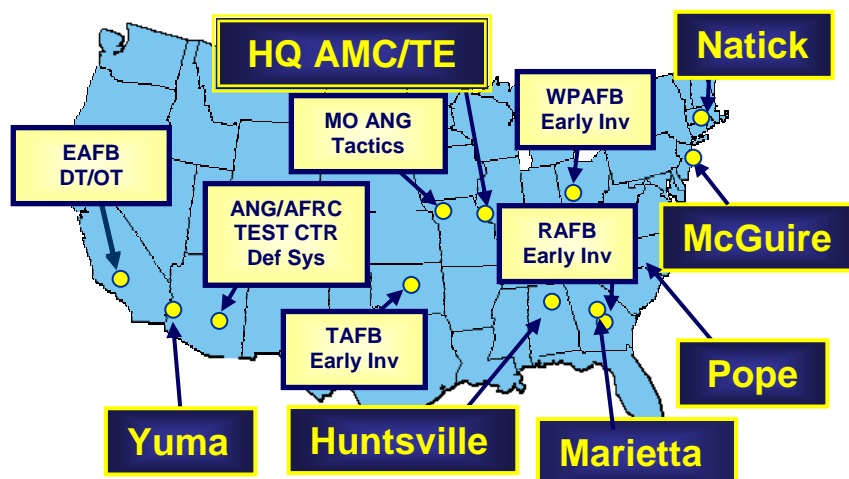


Figure 7. AMC Transformation (yellow boxes denote new locations and primary function)¹⁹

The AMC T&E Transformation represented more than just adding personnel. It was a broad transformation effort designed to build a lean, flexible organization capable of reducing cost for the modern/recap programs.

H. Results: A Lean T&E organization Reduces Modern/Recap Cost

The authors originally determined that 64 positions (at a total cost of \$87 million from FY08 to FY13) were required to meet AMC T&E workload requirements from FY08 to FY13. However, using AFSSO21 achieved a 17% increase in efficiency, and the same amount of workload could be accomplished using only 44 positions (\$70 million investment). Together, the authors determined that the transformation could meet AMC modern/recap requirements by **adding 44 positions and 5 new organizations** throughout the CONUS, as shown in Figure 7. Use of AFSSO21 saved 20 positions and reduced cost by approximately \$17 million. Furthermore, the improved flight sourcing approach (to include added integrated DT/OT) netted an additional \$15 million savings in AMC flight hours. The savings totaled **\$32 million**. However, even larger savings in this transformation lie with the nature of T&E and its ability to identify system defects early in the acquisition process.

In order to explain how these large savings occur, reference Figure 8. As large acquisition programs progress through early acquisition milestones, testing uncovers large lists of deficiencies, depicted by the red bars in Figure 8. At the same time, capabilities are released incrementally up to and beyond initial operational capability of a weapon system, shown by the blue bars. It is important to note the contractor resolves the majority of the deficiencies early in a program, while deficiencies found after fielding result in costly retrofits and larger price tags for block upgrades.

The lists of deficiencies for large programs number in the hundreds. However, large savings are embedded in these lists. Approximately 5 to 10 percent of the deficiencies are what the authors termed “Gems,” or high-dollar deficiencies uncovered by testers. When Gems are found early, fixes are cheaper, and it’s easier to leverage contractor solutions. For example, on a C-5 engine upgrade, an AMC tester uncovered the potential for low reliability and leveraged the contractor for a \$250M redesign cost. This also resulted in an overall system reliability improvement of 5% on the C-5.

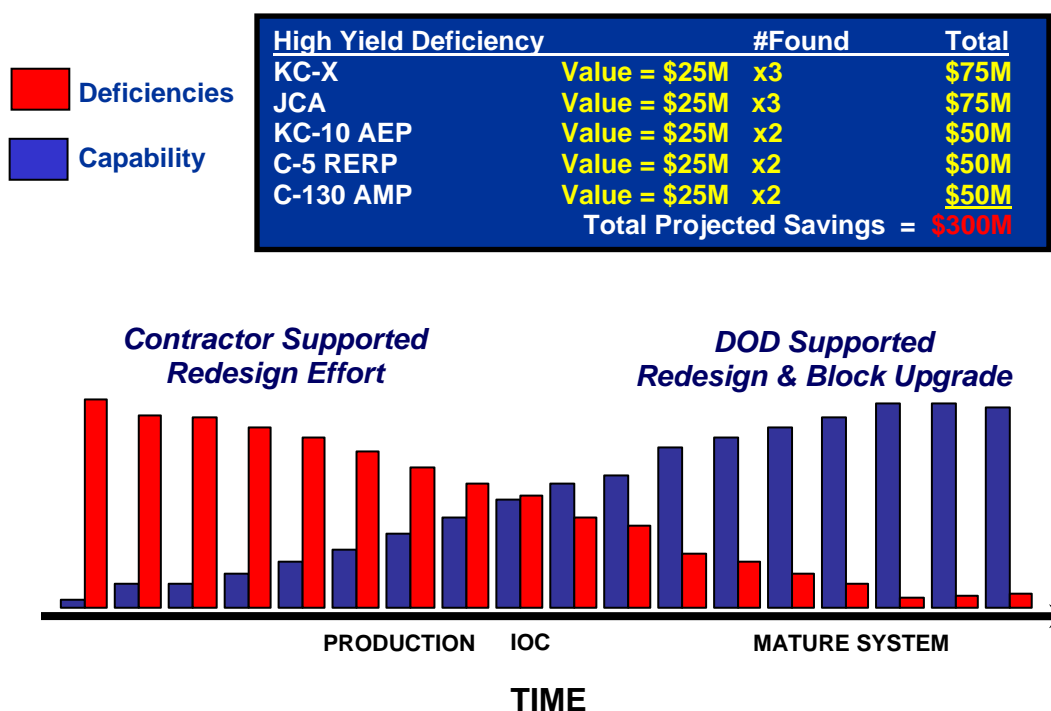


Figure 8. Testers reduce deficiencies, increase capability, and reduce cost

As the system moves forward in development, deficiencies either turn into costly retrofits or add-ons to block upgrade price tags. This can ultimately result in capability gaps for the warfighter. Capability gaps are created when deficiencies progress beyond fielding. In 2005 the C-5 AMP program faced a complete stop of Operational Testing due to a variety of system deficiencies, but primarily due to lagging technical order development. This resulted in a lack of mission ready C-5 AMP aircraft delivered to AMC. Problems were attributed to overtasked

T&E manpower. In this example cascading effects of an excessively lean test force resulted in program delays and capability gaps for the warfighter.

It is important to note the AMC T&E transformation strategy proposes a structure that finds more Gems, but on the left side of Figure 8. That's where program managers can "buy down" program risks that generate cost savings and avoid program delays. The random nature of these Gems make them seem elusive, but the analysis shows that casting out a larger T&E "net" in the right spots yields large savings. This prompts an important question: How many gems are projected with 44 additional testers? With a high degree of confidence, if just 3 gems are found on KC-X and the Joint Cargo Aircraft each, and 2 Gems on the remaining programs listed in Figure 8, an estimate of the magnitude of impact testers have on programs totals \$300 million. Realistically, many in the T&E community expect more Gems to be found, but the numbers shown reflect extremely high confidence. The analysis provides a compelling business case and shows that an efficient T&E force significantly reduces cost on modern/recap programs.

I. Transformation Results

Surely this study was not accomplished just to determine if early user involvement, integrated DT/OT, and use of modeling and simulation is a value-added endeavor. Pundits professing these concepts have been doing so since the Packard Commission in 1986 (the commission established the framework for current acquisition management structure). From Lightning Bolt Initiatives to recent Acquisition Reform laws, policy makers have unveiled "new" concepts in T&E policy nearly every five years since 1986. Yet DOD acquisition programs continue to suffer from significant cost overruns and are the subject of repeated congressional inquiry.

The AMC Test Transformation drove directly to the heart of program instability to find specific T&E links, and subsequently uncovered techniques testers can use to transform their organizations. In this study, actions hinged on maximizing mobility effects. The authors did this by building a stronger connection between the T&E Enterprise and joint effects. In AMC, the authors used EBM to connect the T&E Enterprise to command priorities. They also broke out AFSO21 tools and used a variety of techniques to pinpoint organizational weaknesses. In the course of this study, the authors also uncovered findings systemic to the Air Force T&E Enterprise. The following summarizes the primary findings:

1. T&E is linked to the stability of a weapon system design, and ultimately provides "knowledge early" for program managers to make key milestone decisions.
2. A lean, efficient T&E force sized and positioned properly for projected workload reduces program costs primarily through the discovery of "GEMS," or high dollar defects; ultimately it serves as a direct investment into modern/recap programs.
3. In-depth analysis using industry-approved operations management techniques builds confidence in the ability of T&E to perform its intended function.
4. Testers must use a broad approach to quantify effects for decision-makers and effectively articulate the magnitude of impact T&E can have on modern/recap programs.
5. Ultimately, connecting T&E to the joint fight is a worthwhile endeavor, because it provides a basis for showing how T&E resources bring back "returns" for the warfighter and the taxpayer.

This brings us to the original question posed in the beginning of this paper. Why should PMs invest in T&E transformation? It's simple. **A well-placed investment in T&E can prevent a \$34 billion bill from becoming a \$50 billion over-budget and delayed list of programs.** More importantly, upfront investment in T&E organizations reduces program cost, stabilizes designs, and helps program managers "buy down" the risk of a weapon system program. However, the T&E community must demonstrate good stewardship of this investment using valid business tools. Another key message is in the T&E way of thinking and how it is articulated to program managers: All in all, SYSTEM DEFECTS ARE GEMS TO BE MINED, and form the core antibodies against cascading negative program effects.

Finally, a fundamental conclusion from this study is that modernization and recapitalization programs benefit when the T&E community is "right sized" for efficiency. This way of thinking forms the core basis for building the trust of warfighting commands and program managers. This effort must occur on an annual basis. It must utilize a broad range of tools, with the right level of analysis.

J. A Look to the Future: A Truly Seamless Enterprise Starts with Doctrinal Change

The next cutting-edge step in seamless T&E is the replacement of Developmental and Operational Test with a single integrated T&E doctrine. The DT/OT concept is an antiquated, Cold War model, built for large

bureaucracies. The reality of spiral development and the speed of today's technological advancements may invalidate the need for a separate DT and OT focus. The changing global landscape and the Global War on Terror dictates that a responsive, flexible T&E force focused on joint effects could maximize efficiency for the warfighter and taxpayer.

There are many models available for the Air Force to review in order to research a more seamless doctrine. One potential model for this responsive structure is the Air Force weapons testing infrastructure. Furthermore, other countries (for example, India's Test Establishment or the Israeli Defense Force) also work in resource-constrained environments and follow efficient T&E models dedicated to effects. Industry, NASA, and the FAA already subscribe to a single T&E doctrine, driven partially by funding constraints and the need to build greater profit margins. Studying these organizations could be the key to establishing a seamless enterprise in light of current funding constraints.

Continually catering to the seam between mission effectiveness and spec compliance (referring to Operational and Developmental testing) adds drag to T&E programs, and necessitates the need for two large stove-piped organizations. The speed of acquisition demanded by the warfighter in the Global War on Terror, and the emergence of new threats in today's global landscape are already shaping this environment. Regardless of the solution, the time is now to build new ways of thinking, and remove sources of doctrinal dogma created by the constraints of previous decades. The final question we have to ask ourselves is: are we as a service ready to turn-in our empires, focus on the point-of-effect in the joint fight, and build a truly seamless integrated doctrine?

All of us need to focus on maximizing effect for joint forces. This is not about airplanes or ships. It is about responding at the point of effect for theater commanders.

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³ Schinasi, Katherine V., "A More Constructive Test Approach is Key to Better Weapon System Outcomes," GAO/NSIAD 00-199 (Washington, DC: GAO, July 2000), 4.

⁴ Chester Haines, Deputy Director of Test and Evaluation, Headquarters Air Mobility Command, Scott AFB, provided a significant amount of historical information through interview in Apr of 2006.

⁵ Solis, William M. and Sullivan, Michael J., "Issues Concerning Airlift and Tanker Programs," GAO-07-566T (Washington, DC: GAO, March 7, 2007), 4.

⁶ *Ibid.*

⁷ Chaudhary, Ravi “Transforming American Airlift: Effects-Based Mobility, the C-17 and Global Maneuver,” *Air and Space Power Journal*, Spring 2007 (Maxwell AFB, AL: Spring 2007), 87.

⁸ Air Force Smart Operations for the 21st Century Playbook. Headquarters Air Force, Smart Operations Office (Washington, DC: 27 Nov 2006), 30-40.

⁹ Solis, 13.

¹⁰ Solis, 15.

¹¹ *Ibid.*

¹² McQueary, Charles, Director, Operational Test and Evaluation, Annual Report 2006 (Washington, DC: OSD, December, 2006), 167-219.

¹³ Fox, Bernard, Boito, Michael, Graser, John, Yonossi, Obaid, “Test and Evaluation Trends and Costs for Aircraft and Guided Weapons,” RAND MG109 (Washington, DC: May 29, 2004), pg 108.

¹⁴ Sue Payton made this address as a keynote speaker at the annual Airlift Tanker Association Convention, October 2007.

¹⁵ Chaudhary, 87.

¹⁶ The AMC/CC’s Commander’s Intent, primarily the concept of “Velocity and Precision,” was sourced from the Air Mobility Command briefing chart, supplied by the Headquarters AMC Commander’s Action Group, AMC/CCX, Jun 2007.

¹⁷ Winston, Wayne, *Operations Research, Applications and Algorithms*, Third Edition. (Duxbury Press, Belmont, CA: 1994), 799.

¹⁸ Schinasi, 29. (Washington, DC: GAO, March 7, 2007)

¹⁹ Lt Col Christy Kayser-Cook, Chief of Test Policy for HQ AMC, developed the organizational design presented in this figure and also provided significant inputs to the various designs which formed the basis of the mathematical models used in this paper.